The Tribological Behaviours of New and Existing Self-lubricating Materials for Space

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European Space Tribology Laboratory (ESTL)

European Space Mechanisms and Tribology Symposium

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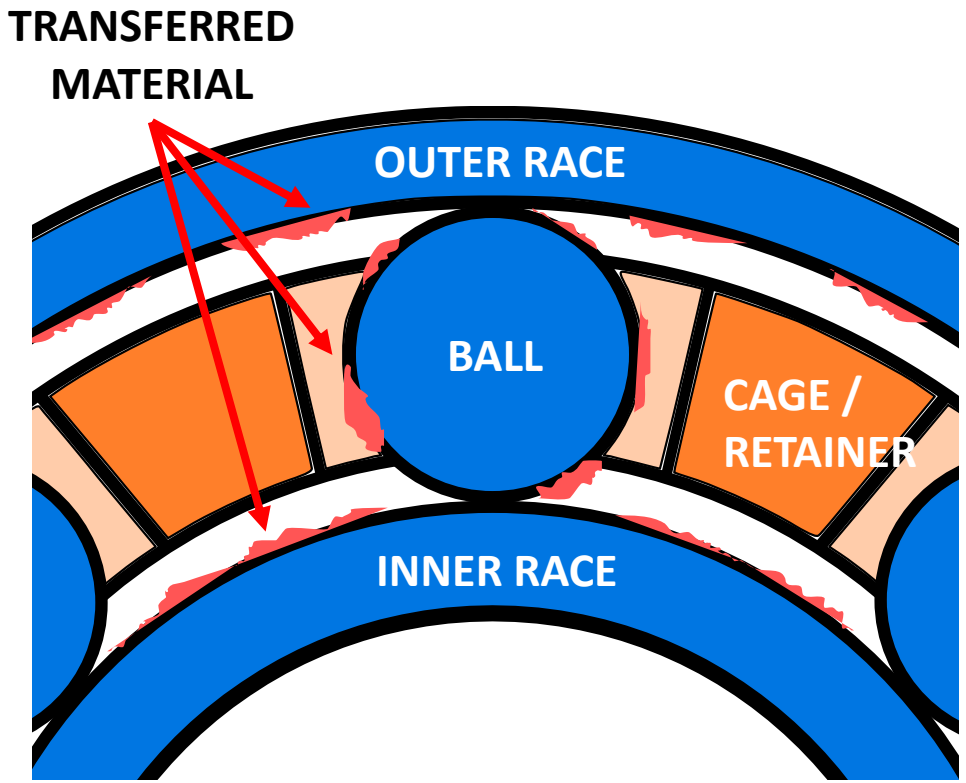
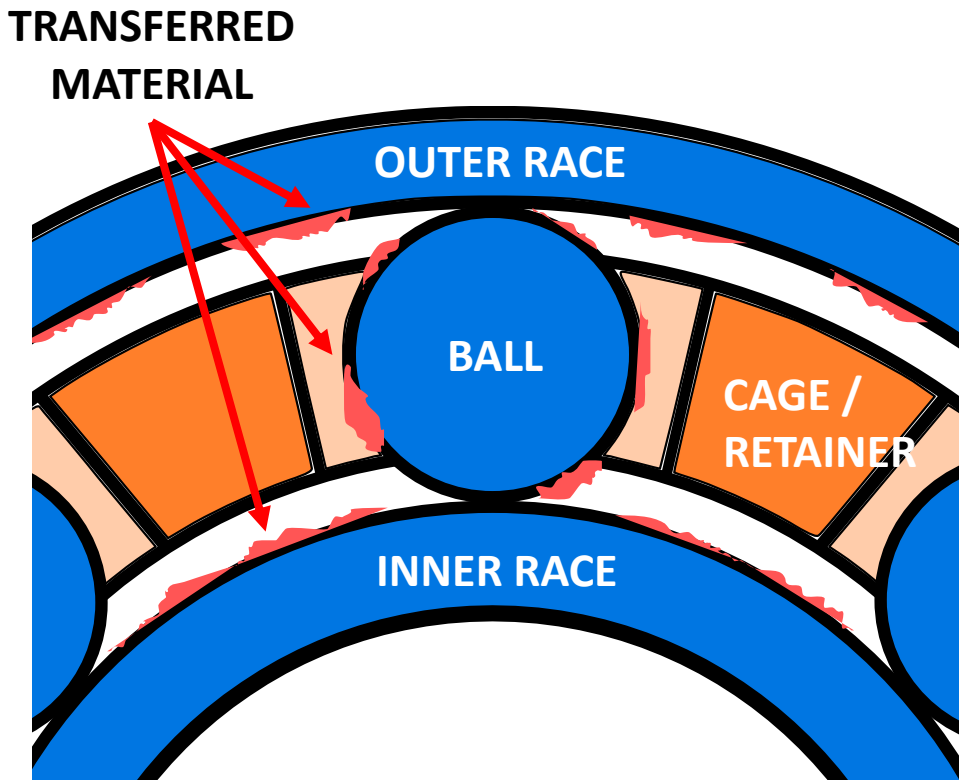
ESR Technology
Engineering, Safety & Risk

Double Transfer Mechanism



Double Transfer Mechanism

- Bearing parts coated in solid film:
  - MoS_2
  - Lead



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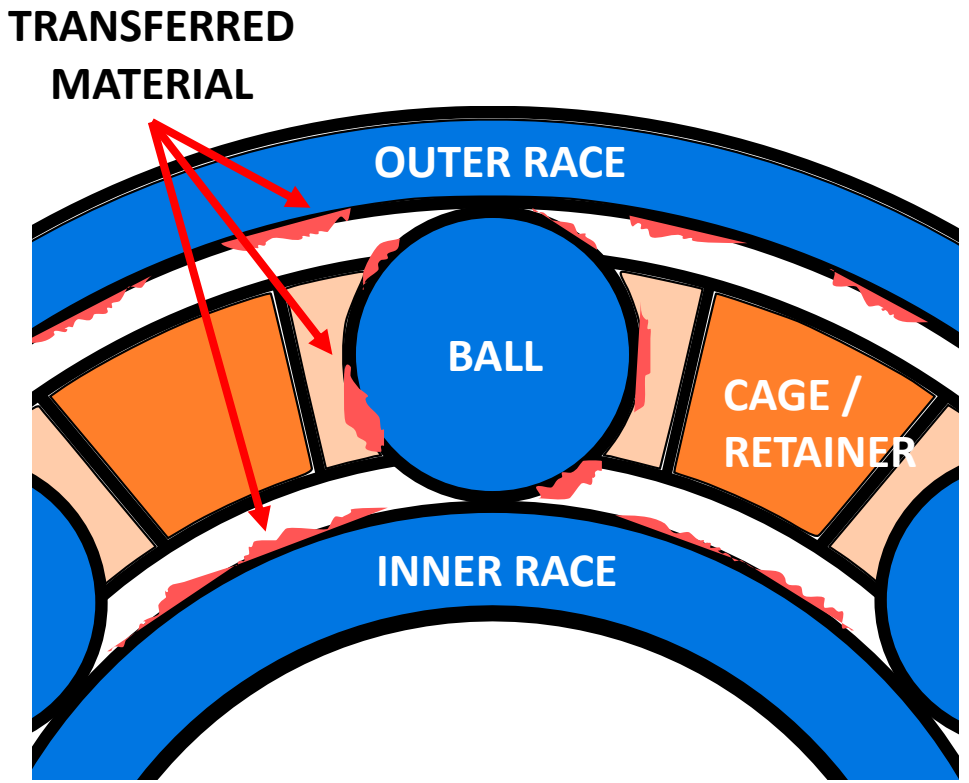
- Complimentary cage material:
  - PGM-HT
  - Lead/Bronze



Double Transfer Mechanism

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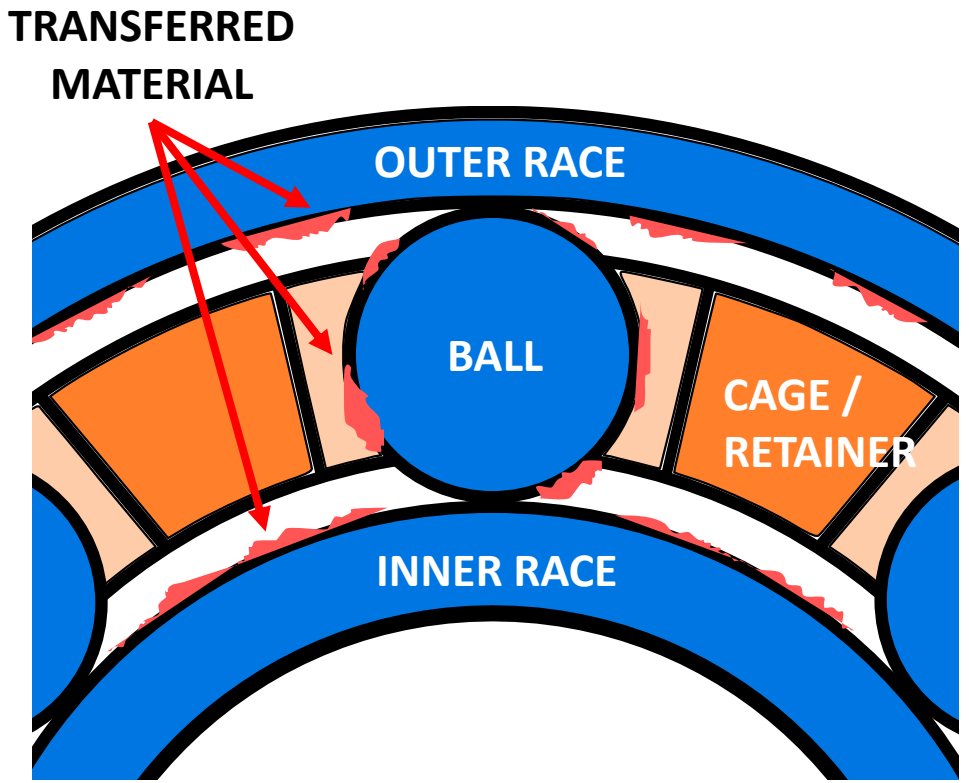
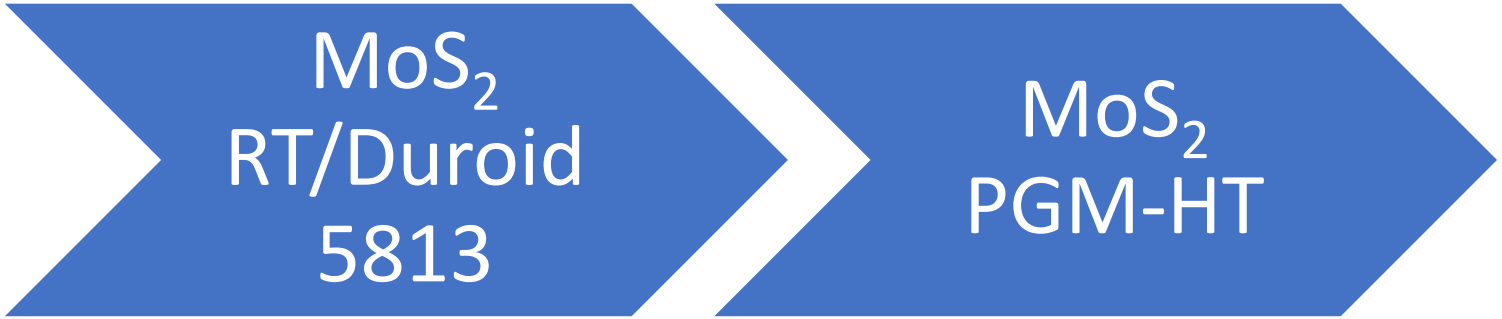
- Cage -> Ball -> Raceway



SLM History

MoS_2
RT/Duroid
5813

SLM History

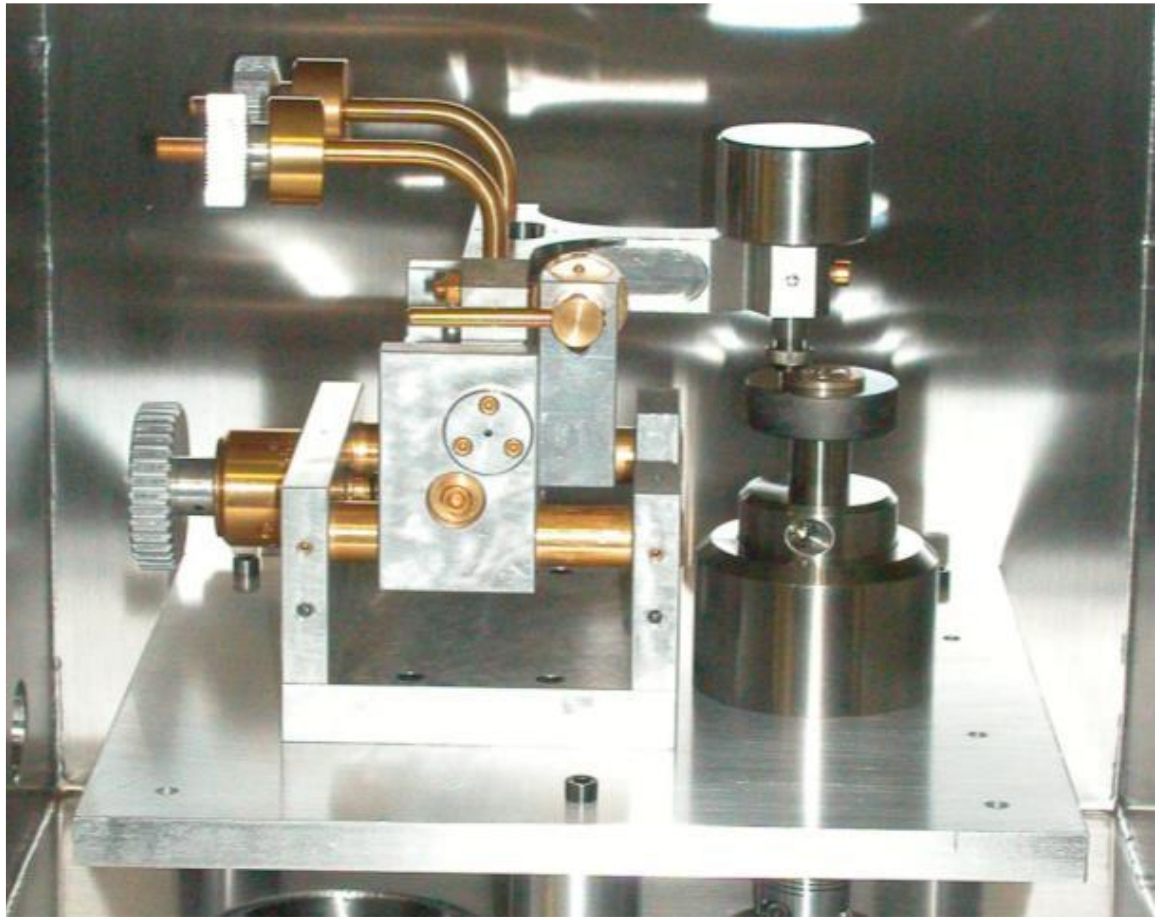


SLM History

SLM History

- Similar or better friction performance than PGM-HT
- Resistant to operation in air
- EU sourced

Traditional Methods



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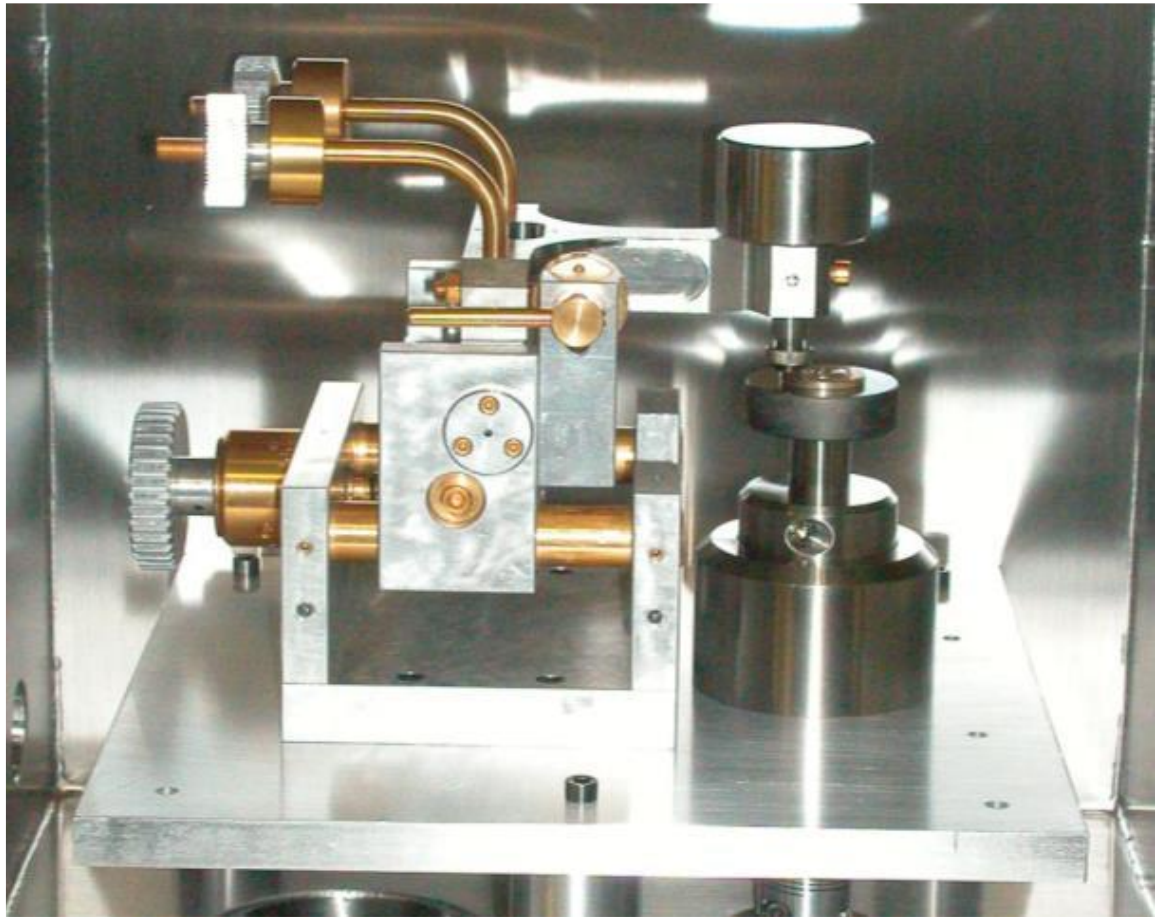
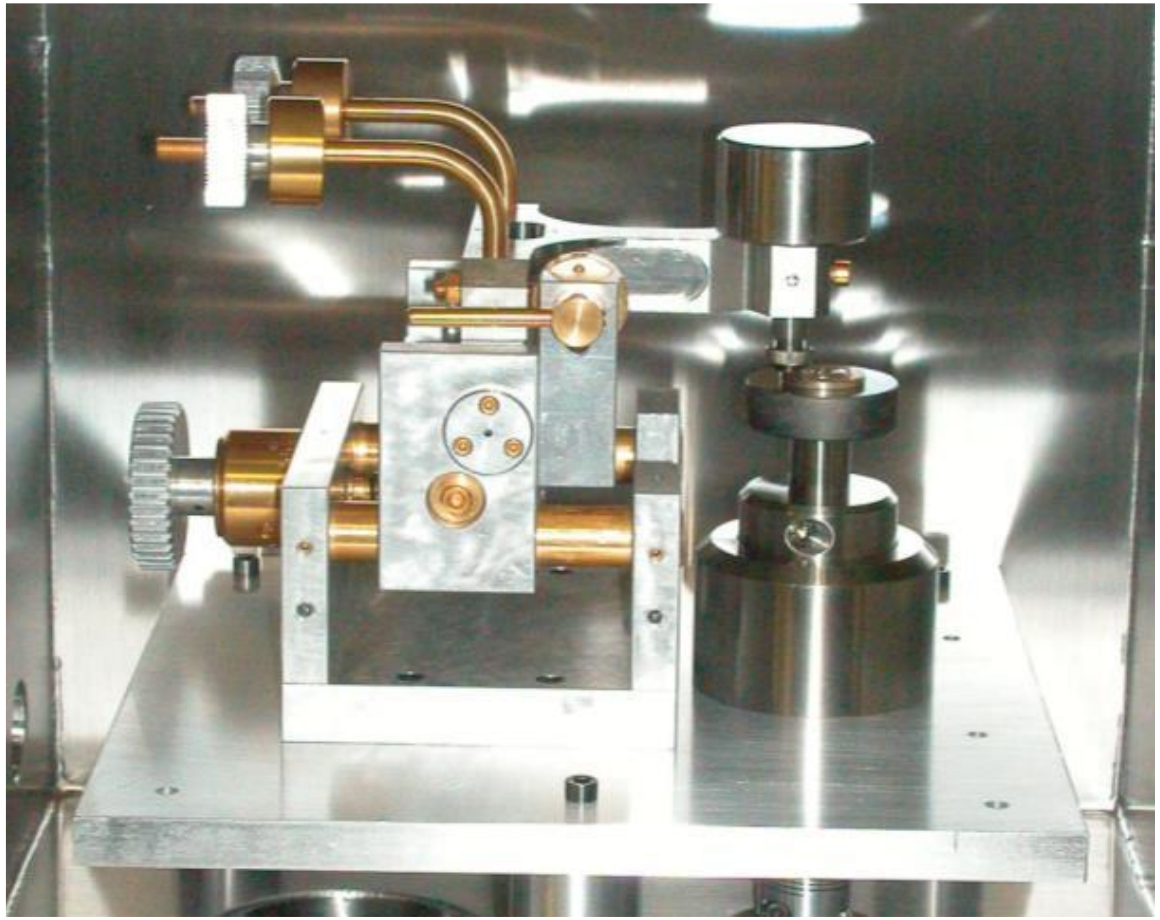


- Pin made of SLM against steel disc

Traditional Methods



- Pin made of SLM against steel disc
- Easily change:
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  - Temperature
  - Sliding Speed
  - Environment

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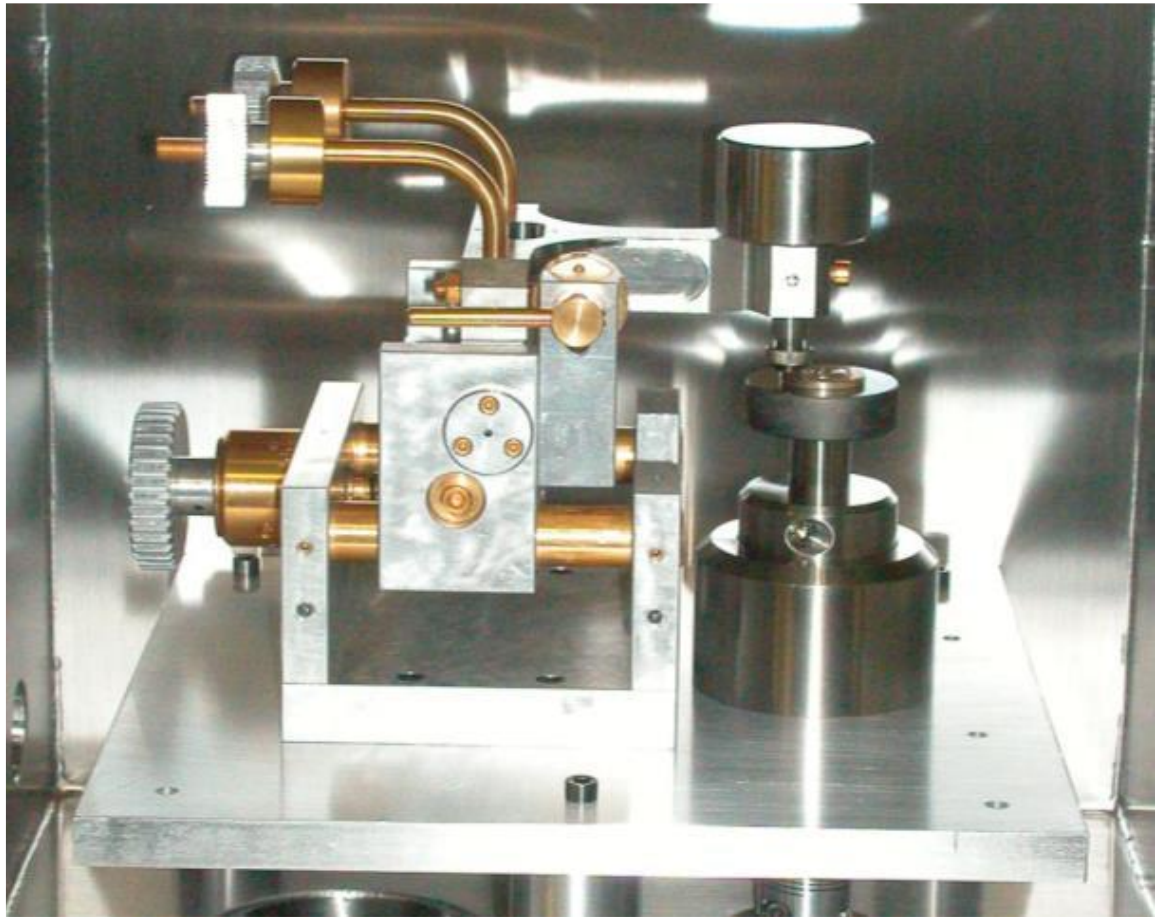
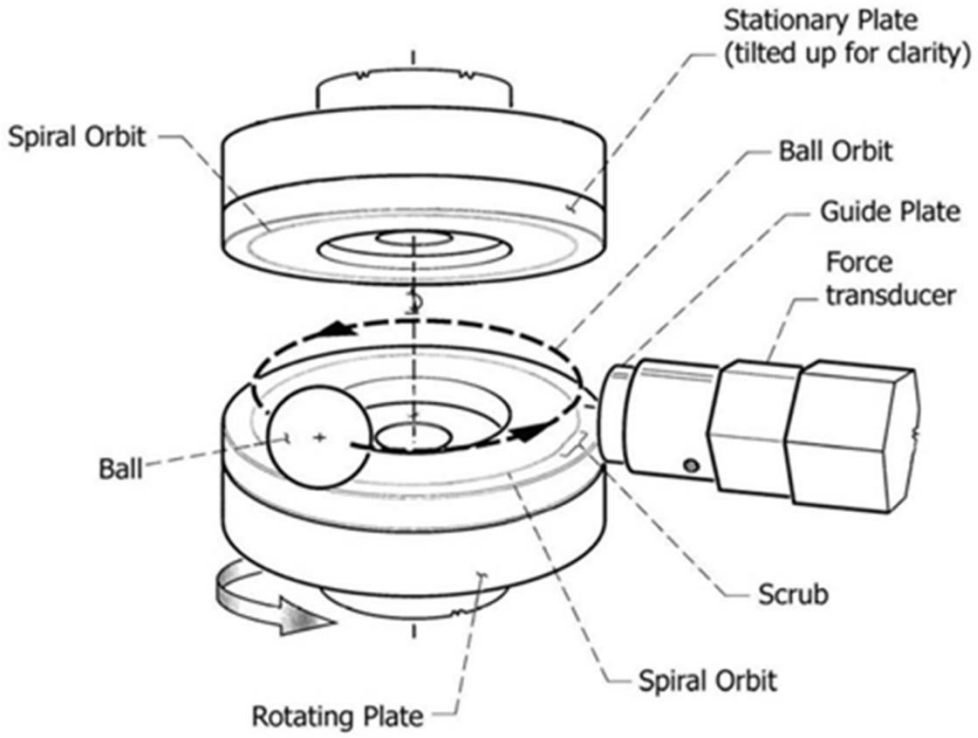


- Pin made of SLM against steel disc
- Easily change:
  - Load
  - Temperature
  - Sliding Speed
  - Environment
- Sliding representative of cage/ball contact but not double transfer mechanism

Spiral Orbit Tribometer



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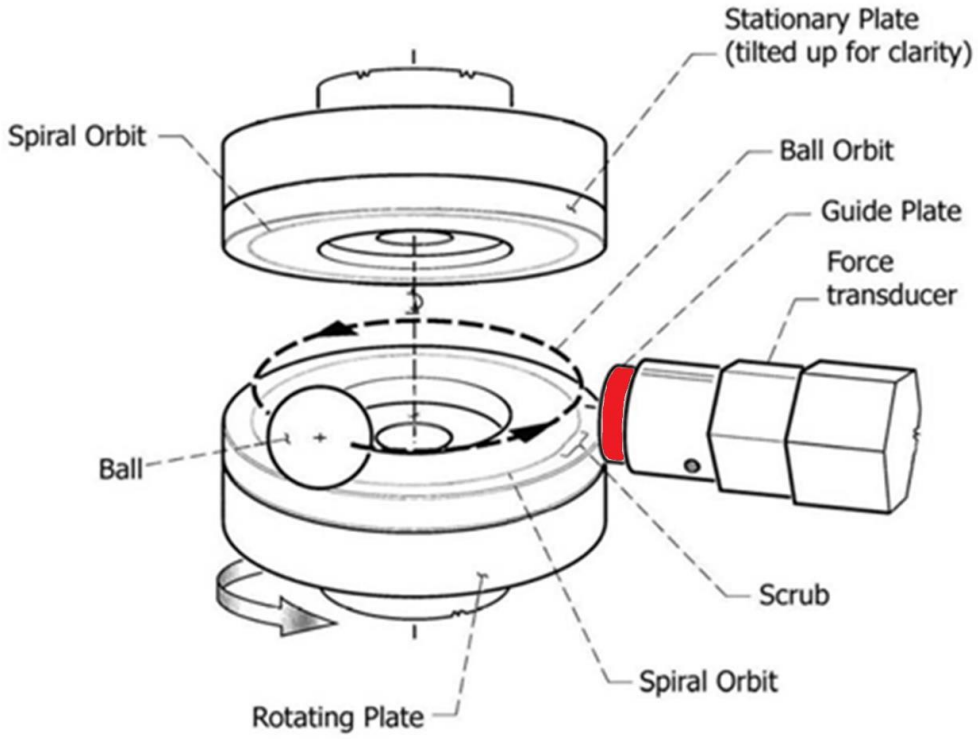

- Guide plate manufactured from SLM

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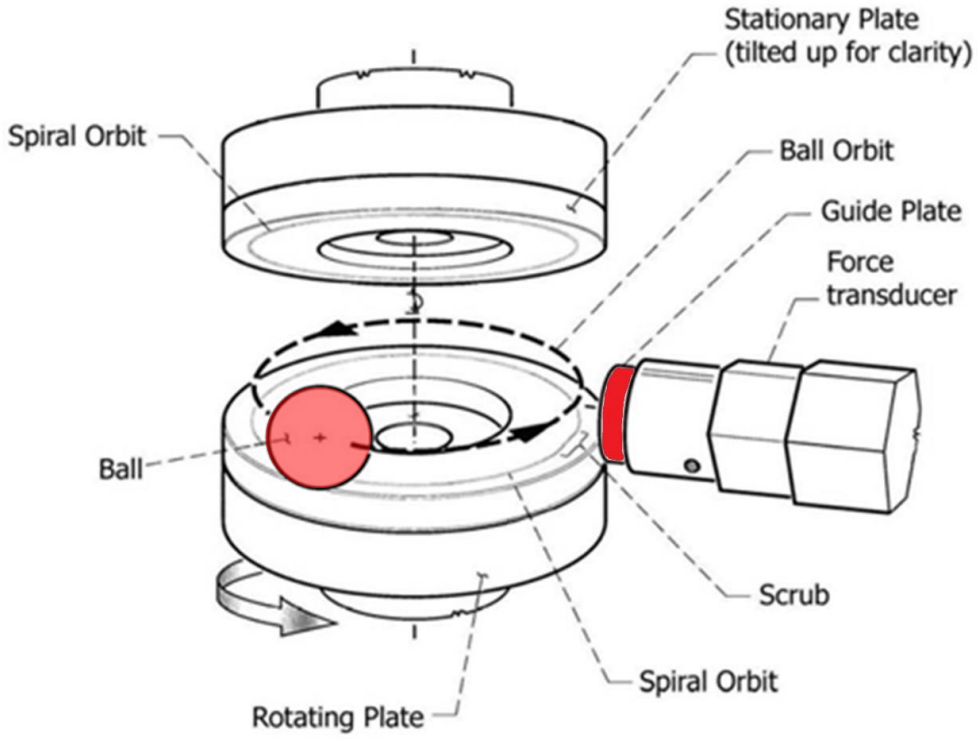

- Guide plate manufactured from SLM
- Material transfers to ball during collision with guide plate

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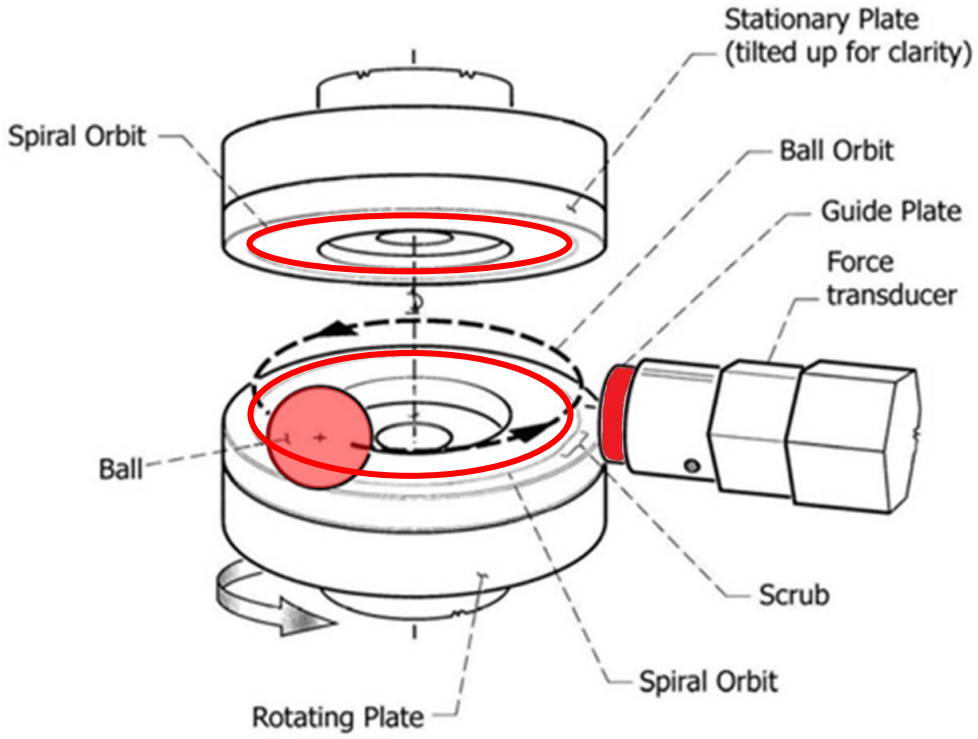

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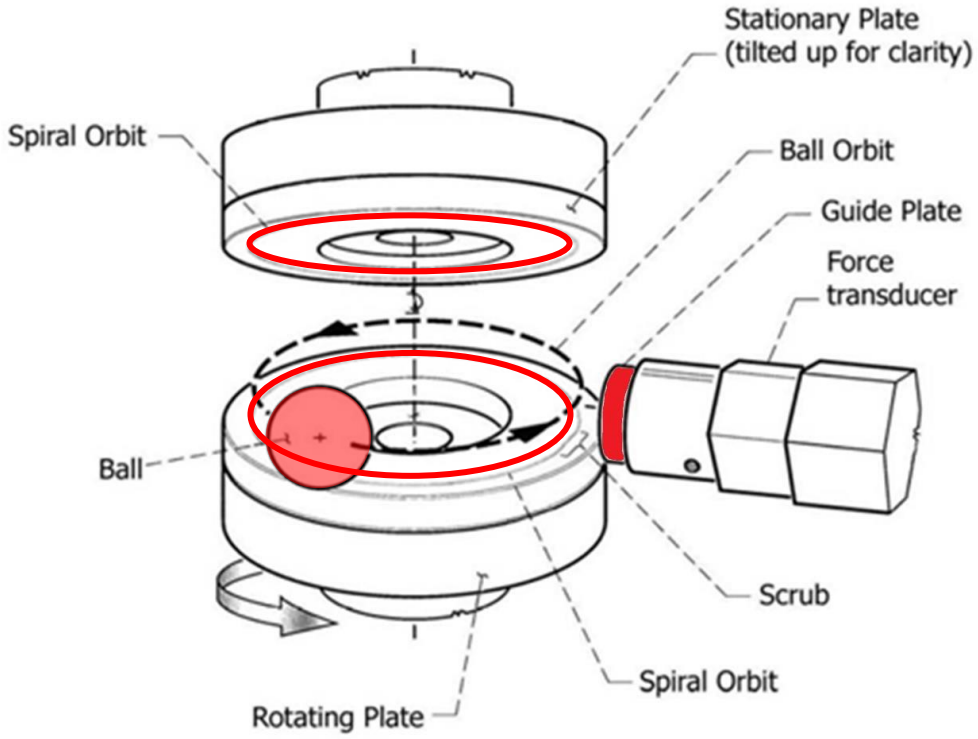

- Guide plate manufactured from SLM
- Material transfers to ball during collision with guide plate
- Material transfers to plate from ball
- Allows for examination of transfer film formation on plates

SOT Test Results

ESTL
Keeping Space Moving

Material	CoF (Mean)	CoV	Mo Thickness (um)
RT/Duroid 5813	0.270	41.5%	0.362
PGM-HT	0.187	53.6%	0.359
TSE8591	0.211	55.2%	0.353
C79	0.301	26.5%	0.356
Vespel SP3	0.498	26.8%	0.383
Tecasint 2391	0.561	23.3%	0.368

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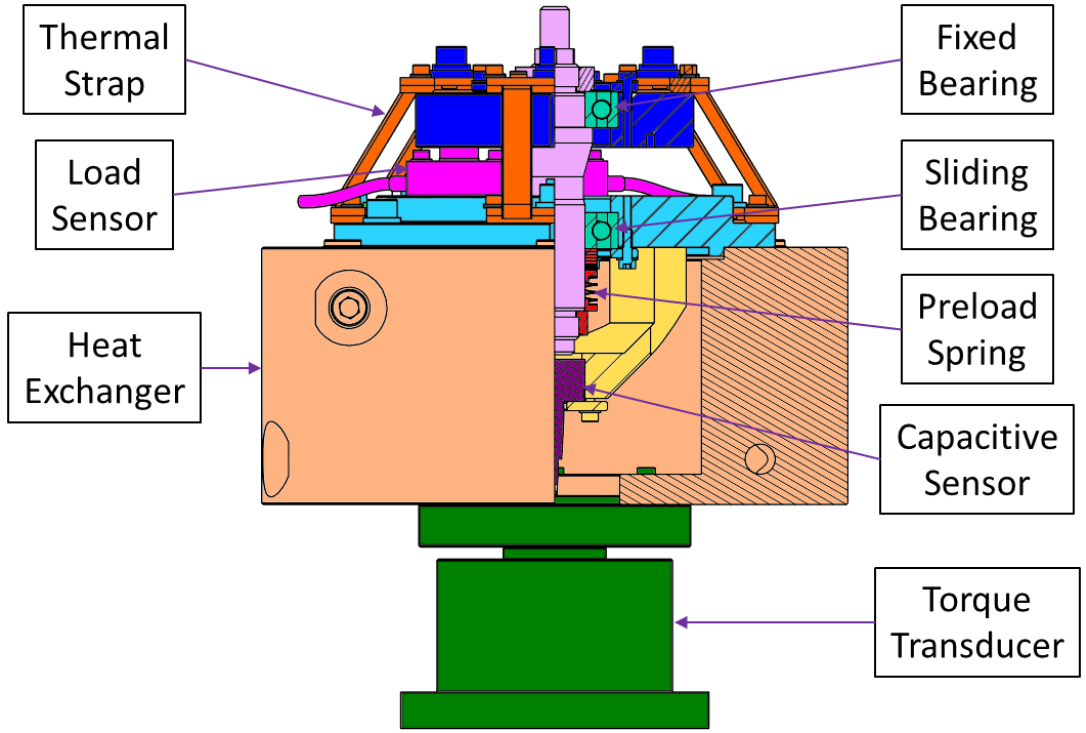
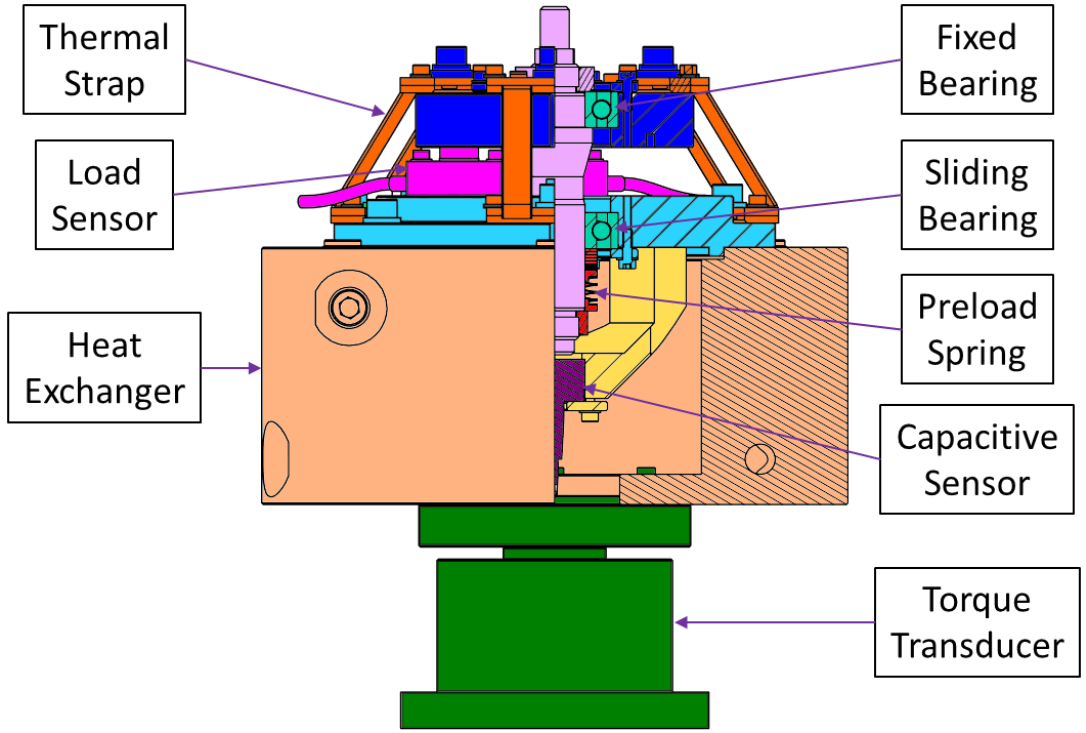
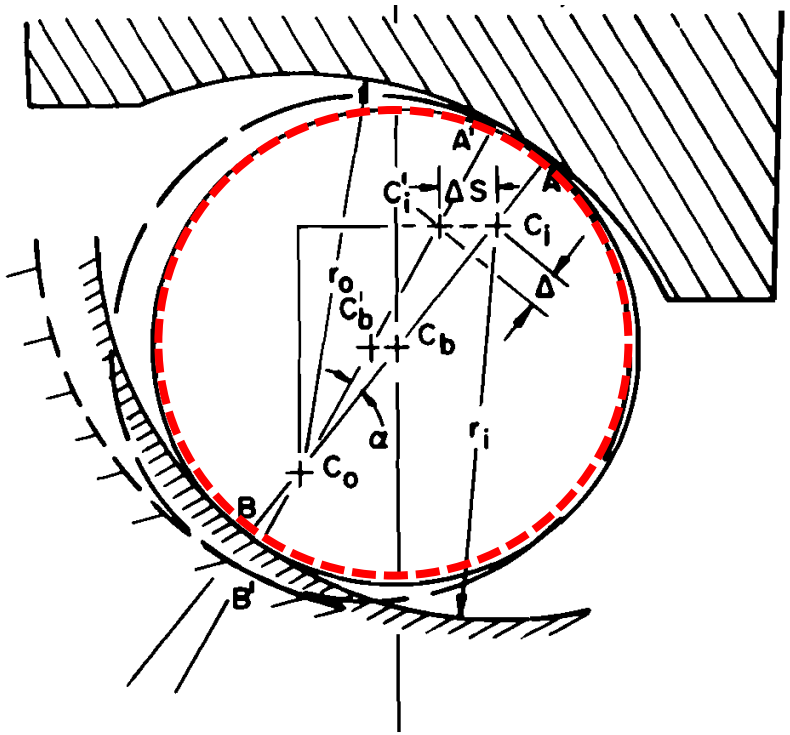
- PGM-HT/TSE8591 have similar friction properties
- Mo XRF measurements indicate stable film formation on balls
- Post test inspections show PGM-HT film highly variable compared to uniform homogenous films of Duroid/TSE8591

Advanced Bearing Test Rig



ABTR





(Tyler et al, 1979, EHD Film Thickness Behaviour in DMA Bearings)

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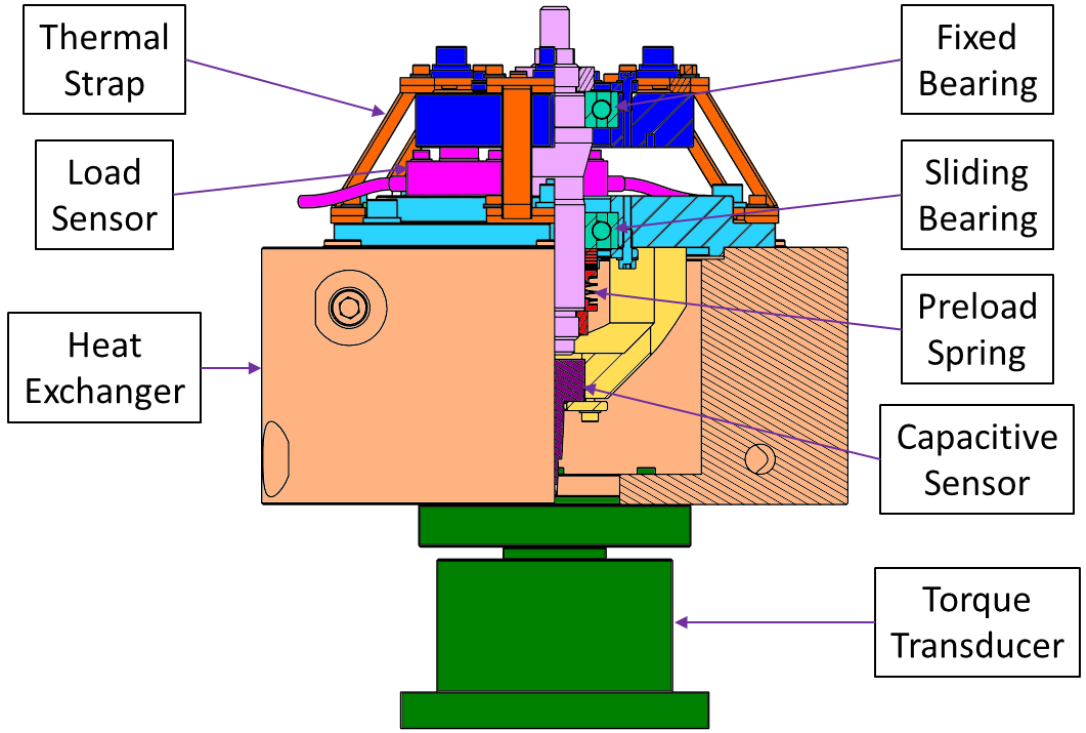

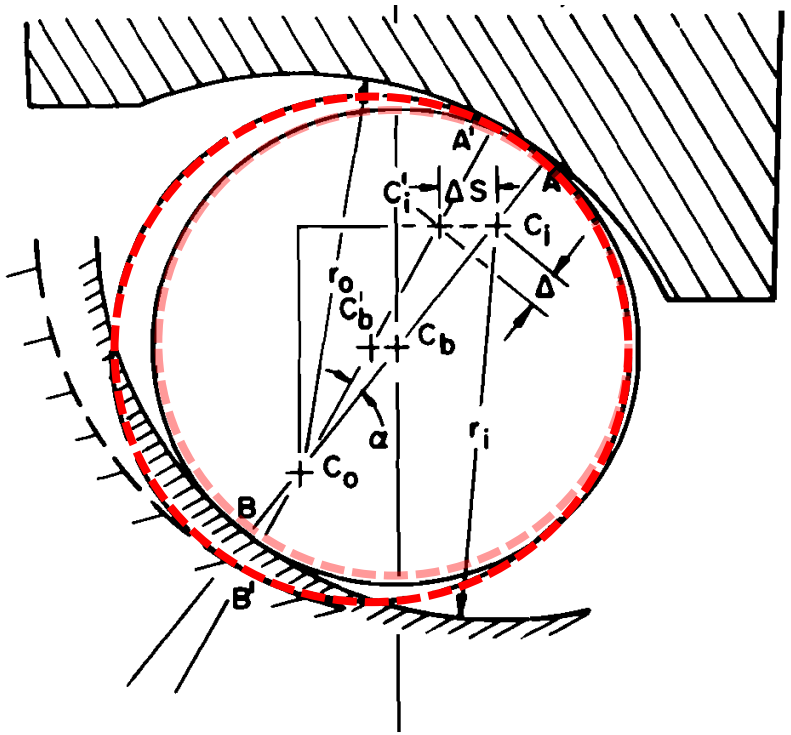

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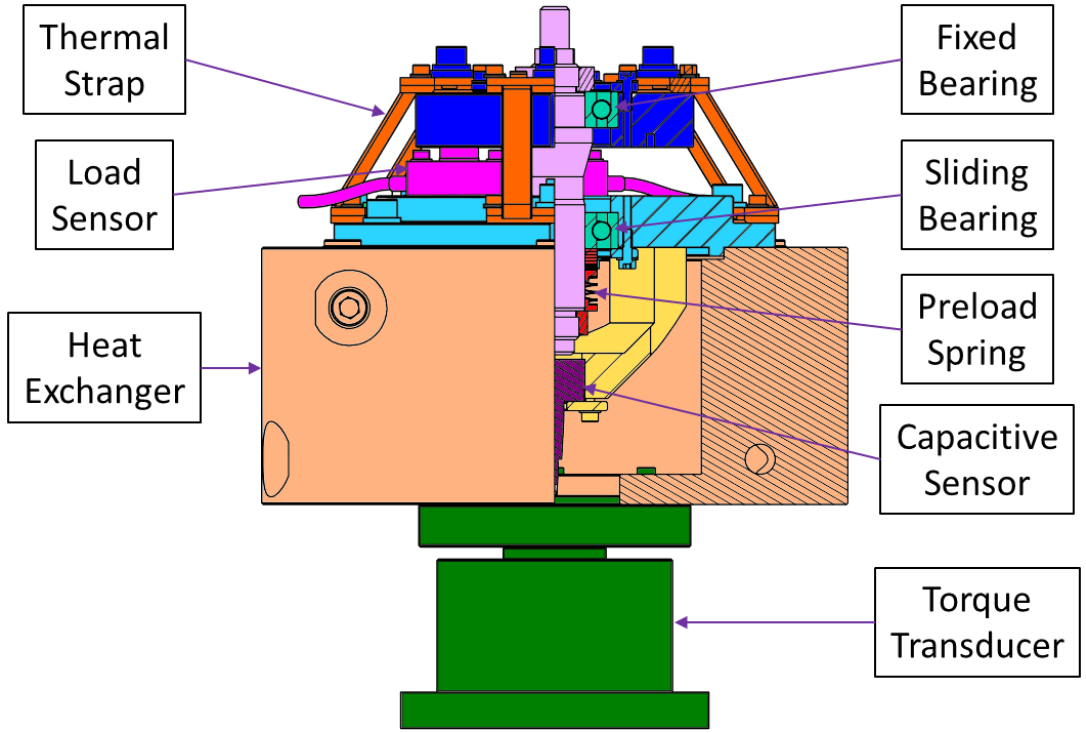

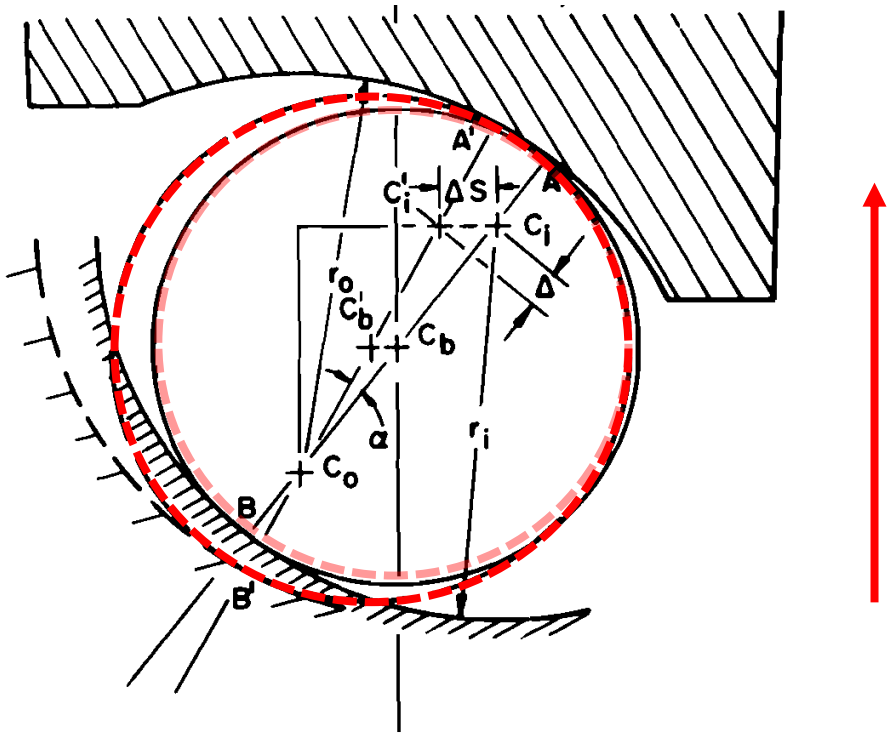

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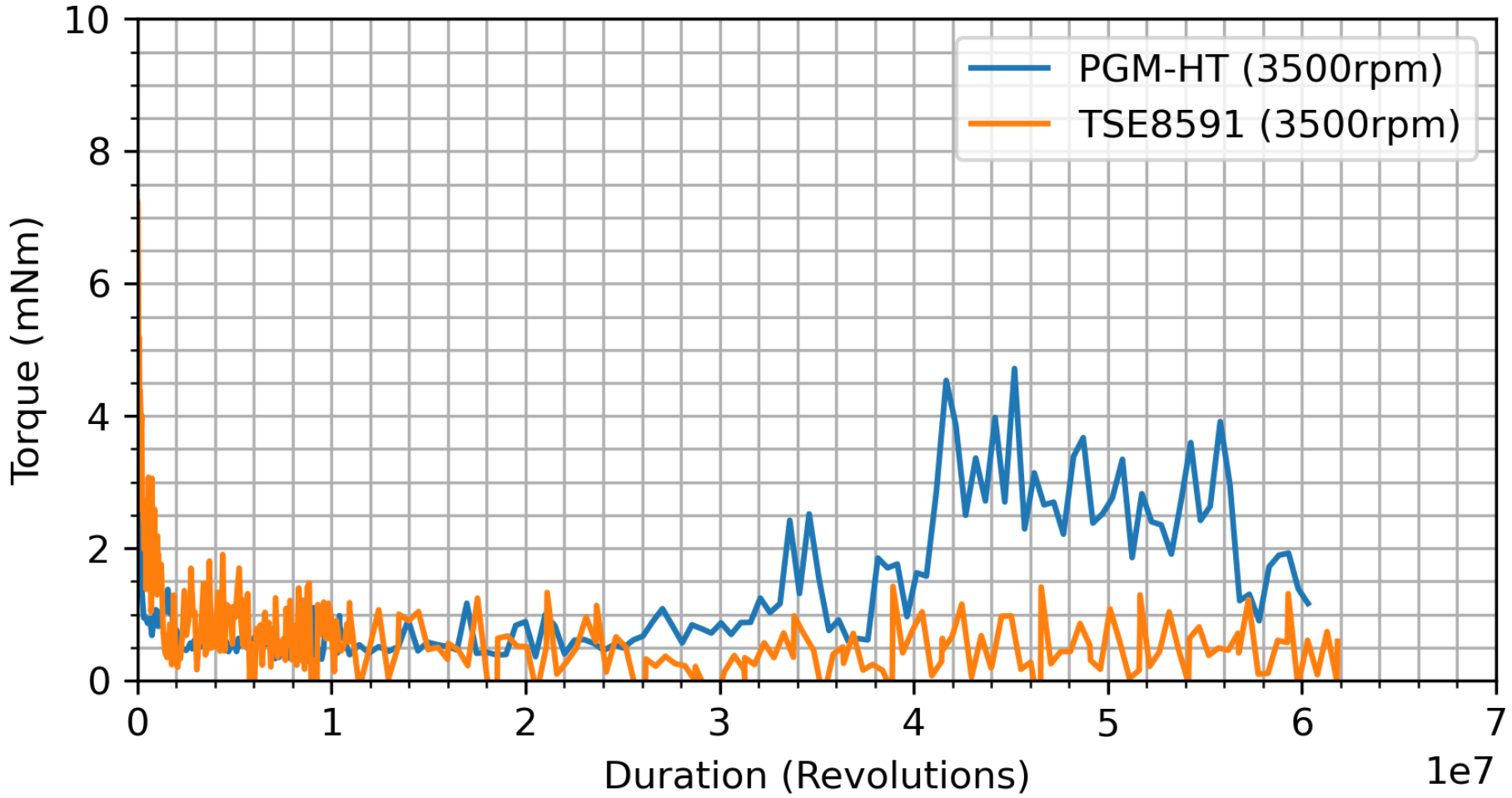

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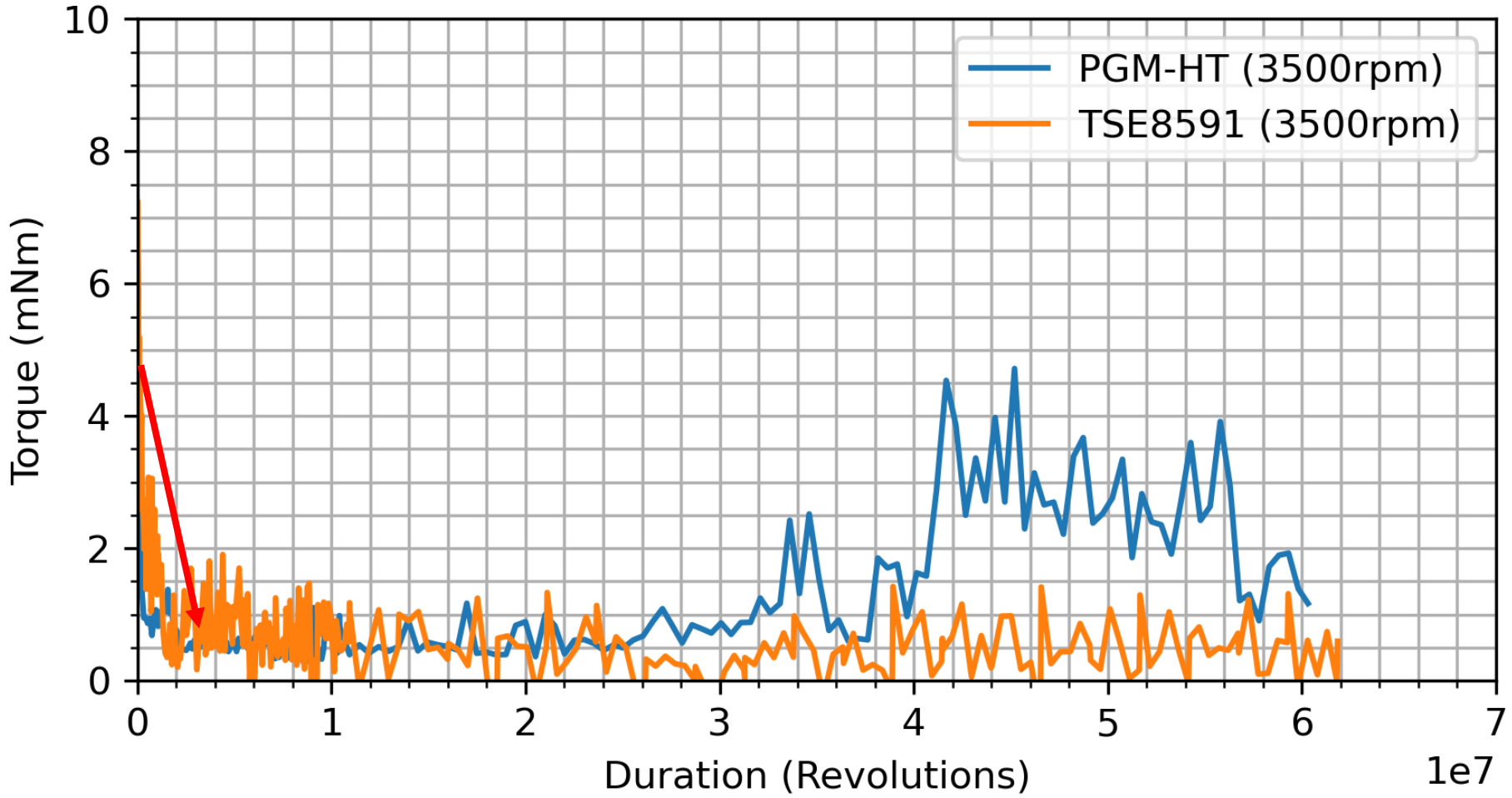

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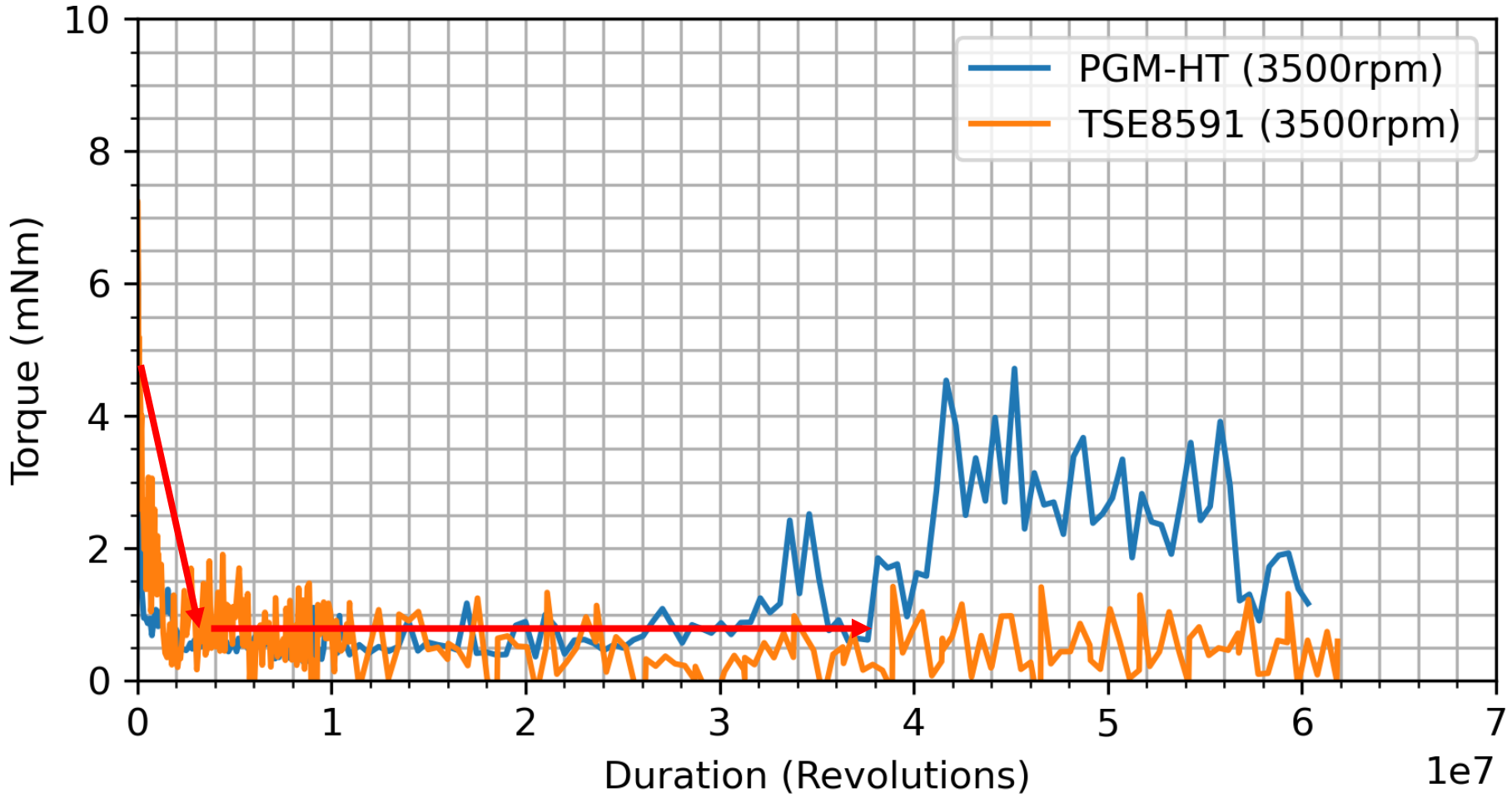

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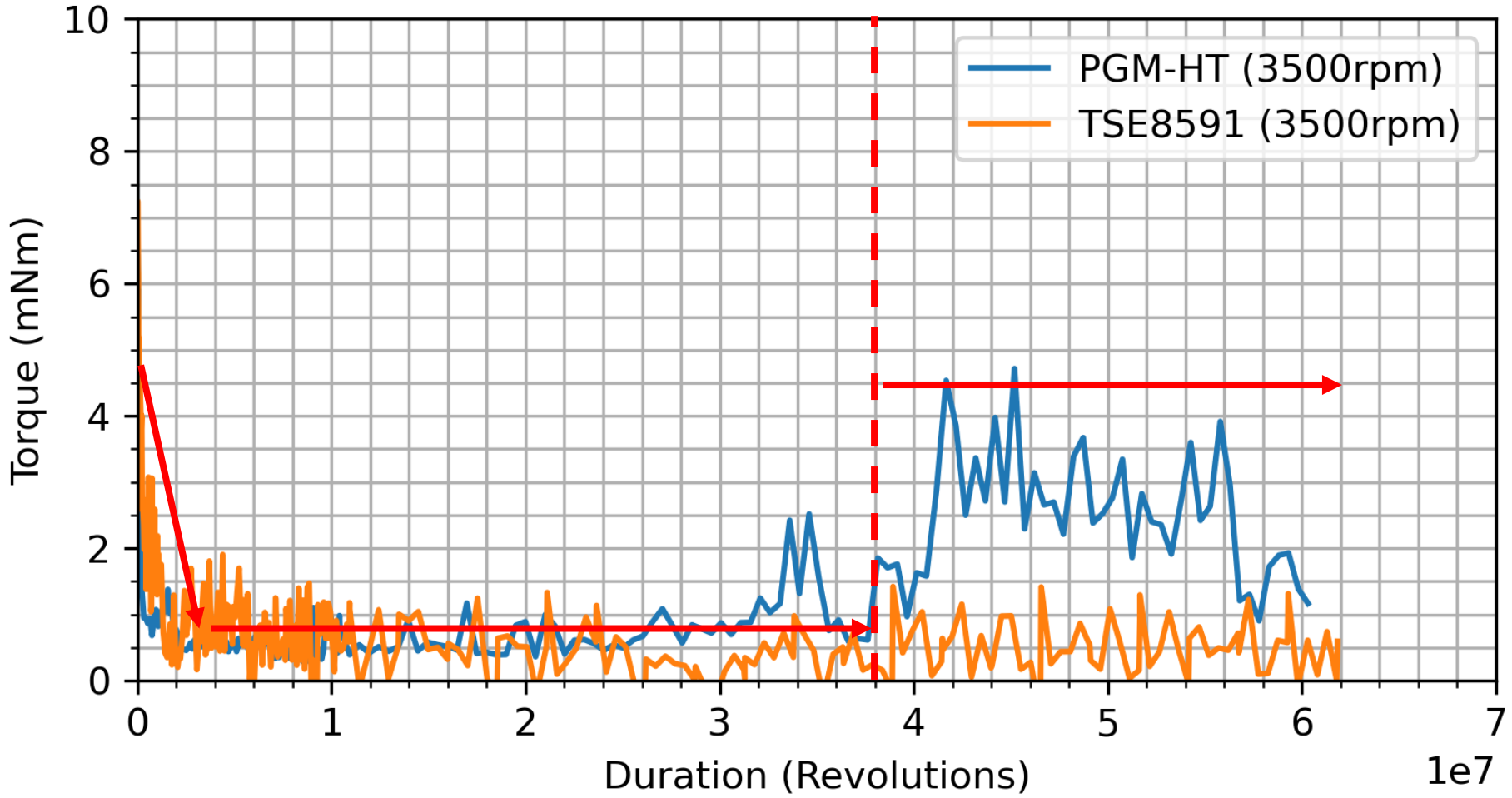

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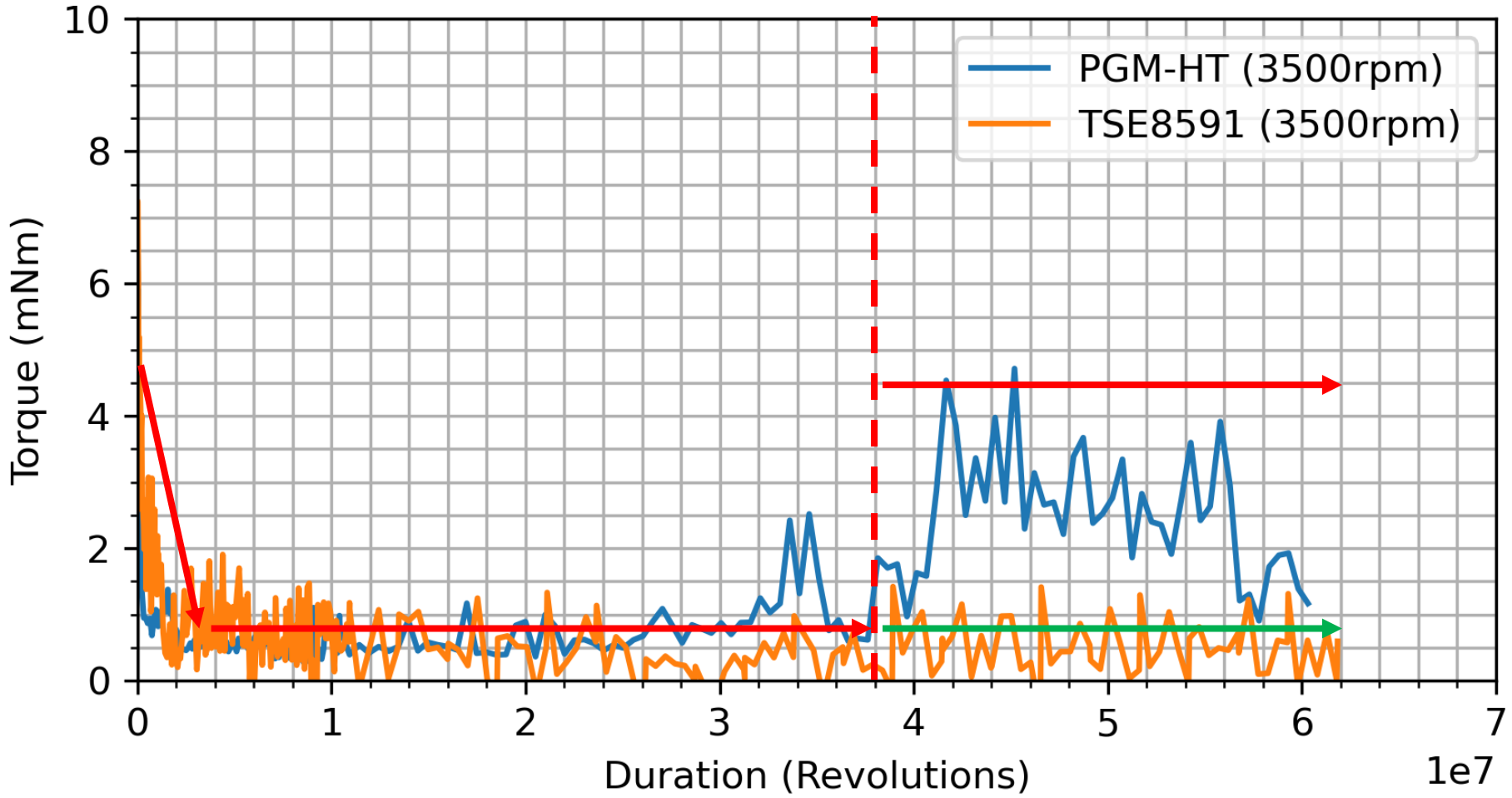

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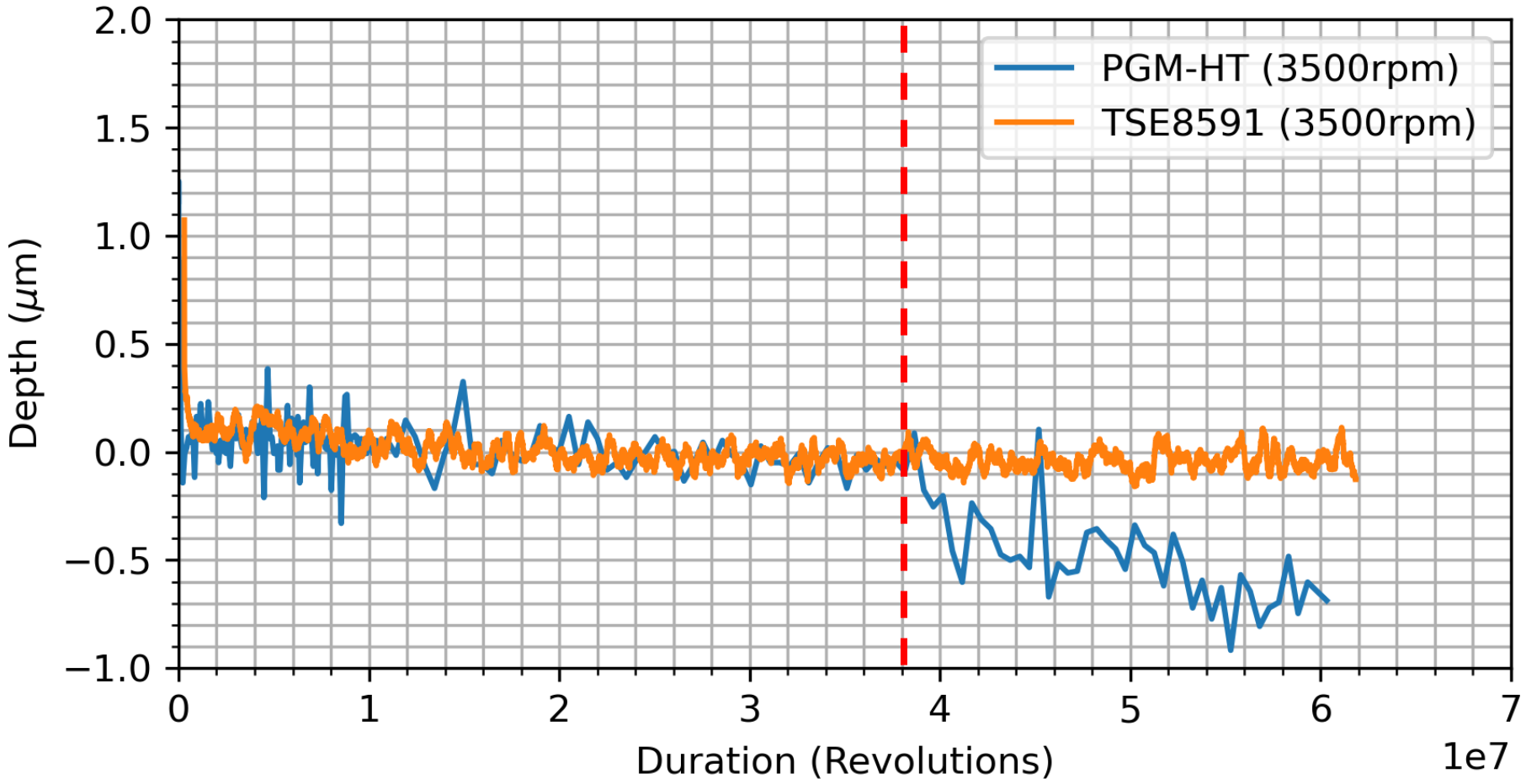

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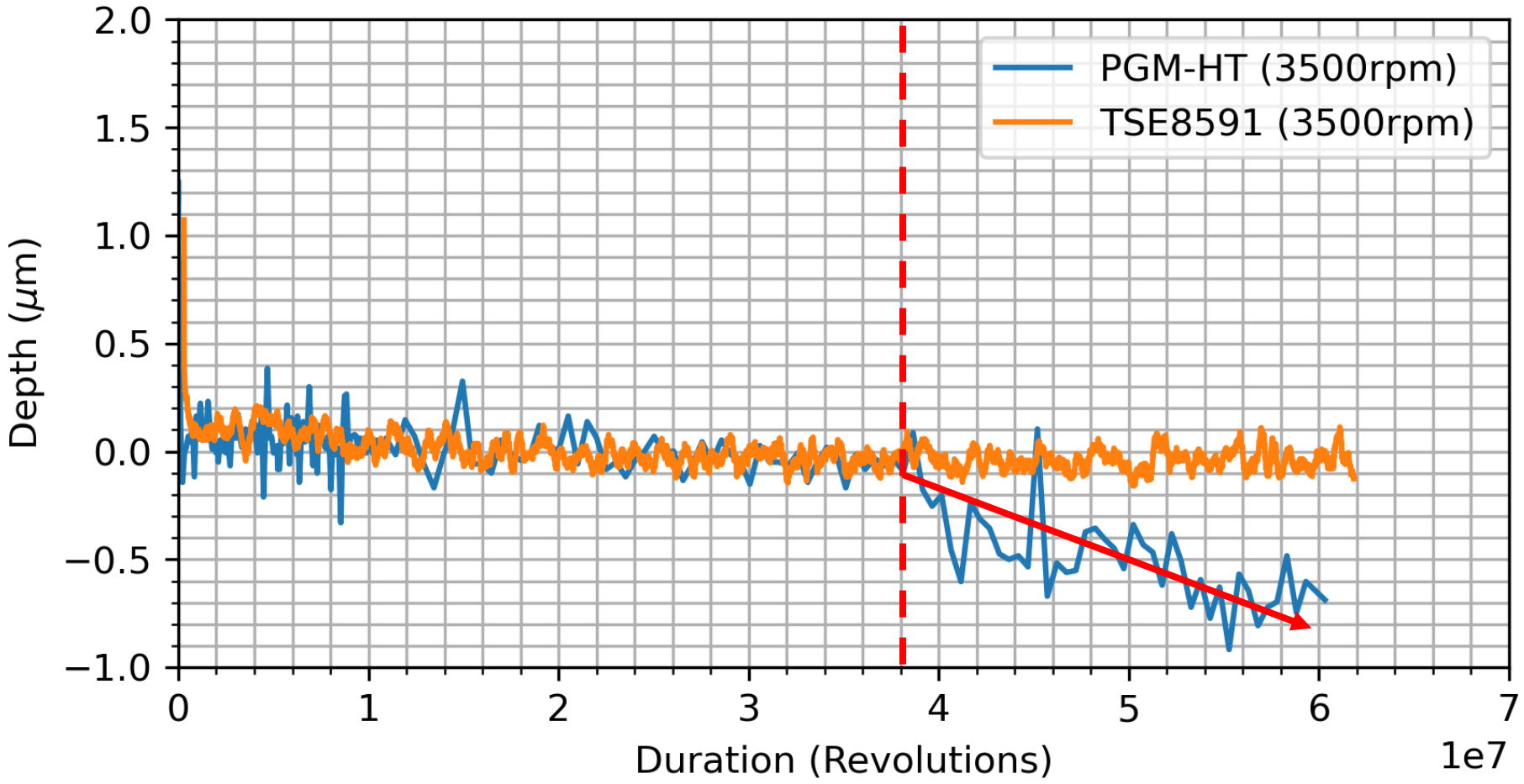

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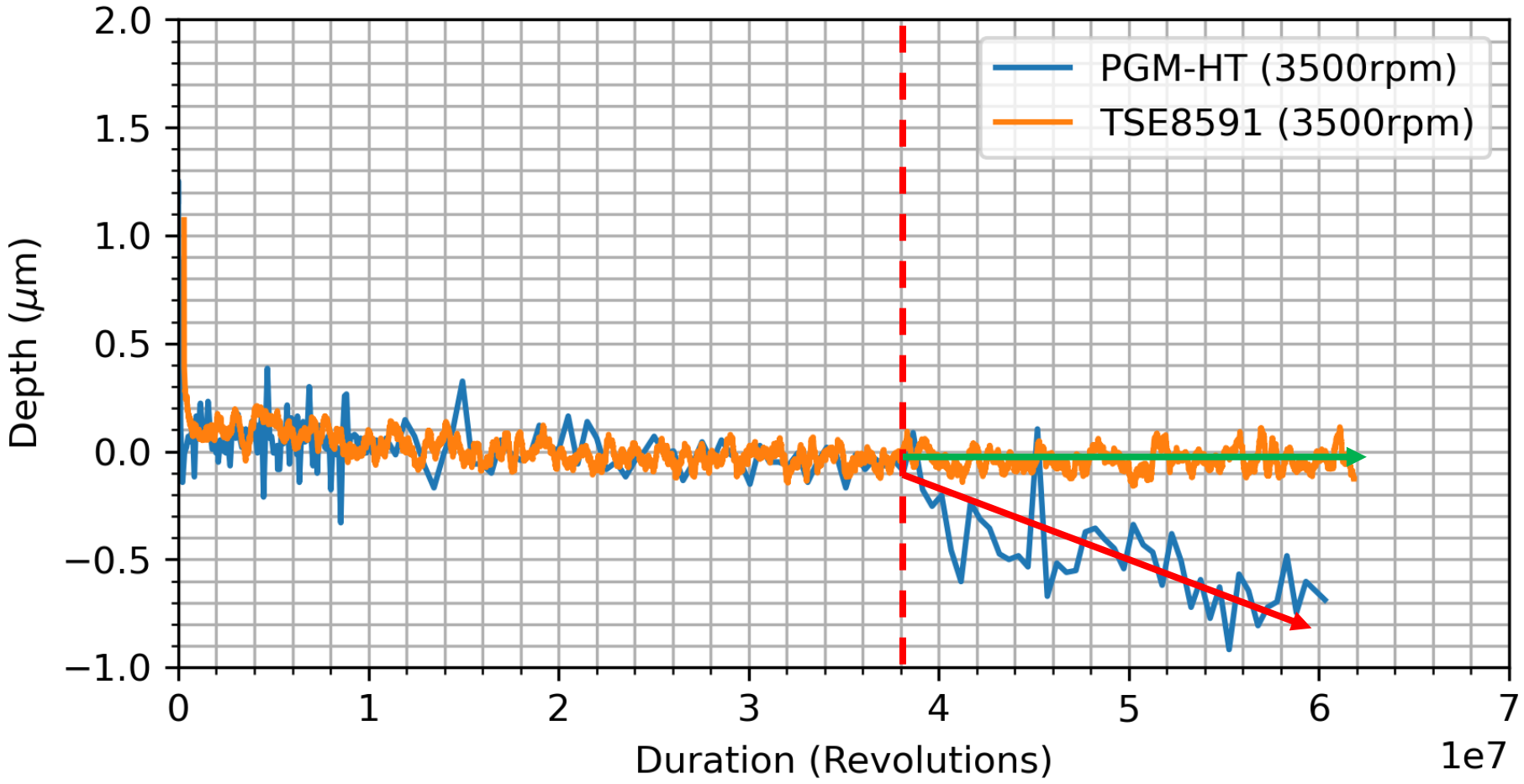

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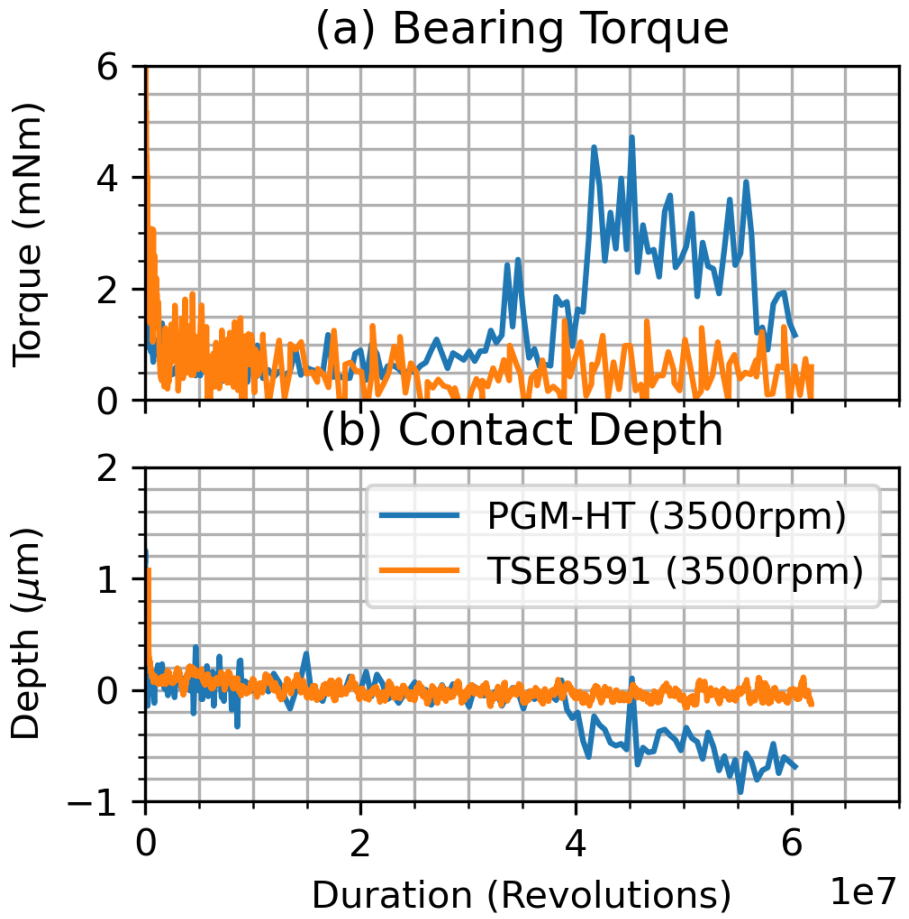
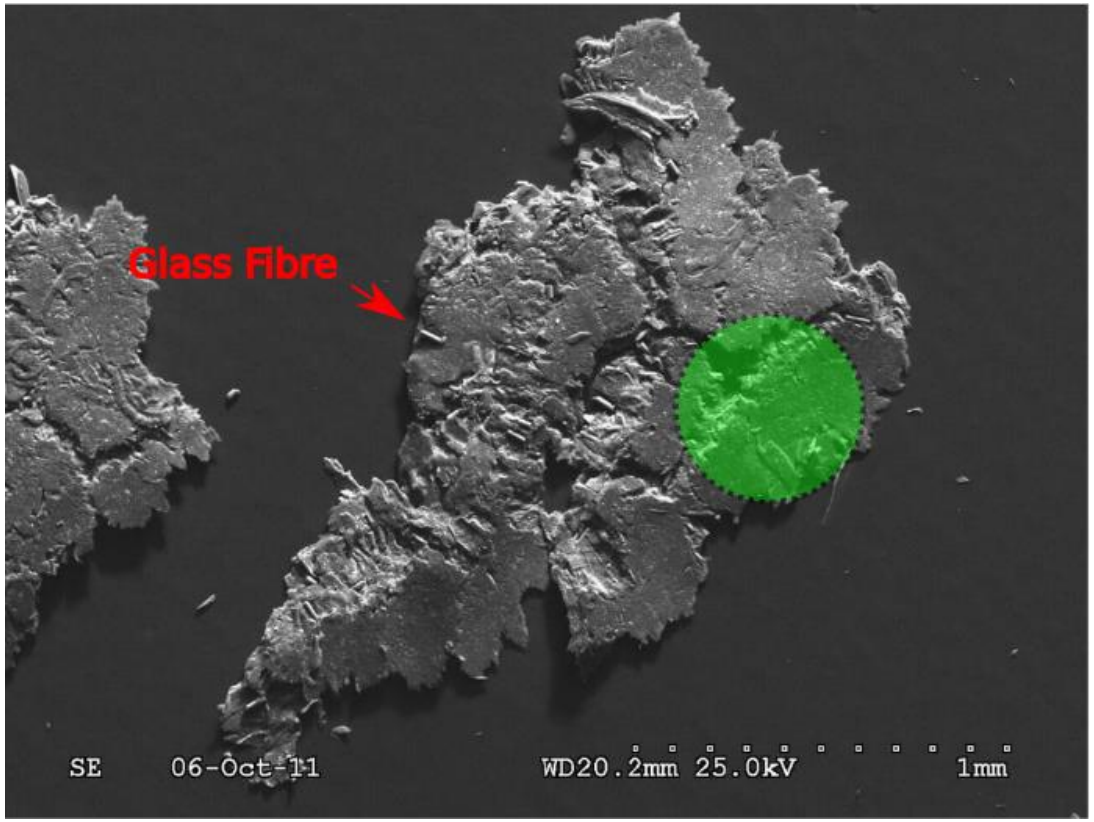


- Clear difference in friction behaviour
- Change in friction behaviour accompanied by change in film thickness
- TSE8591 remains stable until the end of the test

Material Comparison



Parameter	Unit	PGM-HT	TSE8591
CoF	-	0.187	0.211
CTE (HT)	10^{-6} / K	63	65
Yield (HT)	MPa	5.10	5.60
Fibre Diameter	µm	~20	~3

(High Temperature (HT) data from AAC SLMC2 presentation from FPD 2020)

SLM Validation

Activity	PoD	SOT	Bearing
Assessment of new SLM sliding friction/wear properties	●		

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Assesssment of SLM performance in bearings in different environments (Air/Vacuum/Thermal)			●

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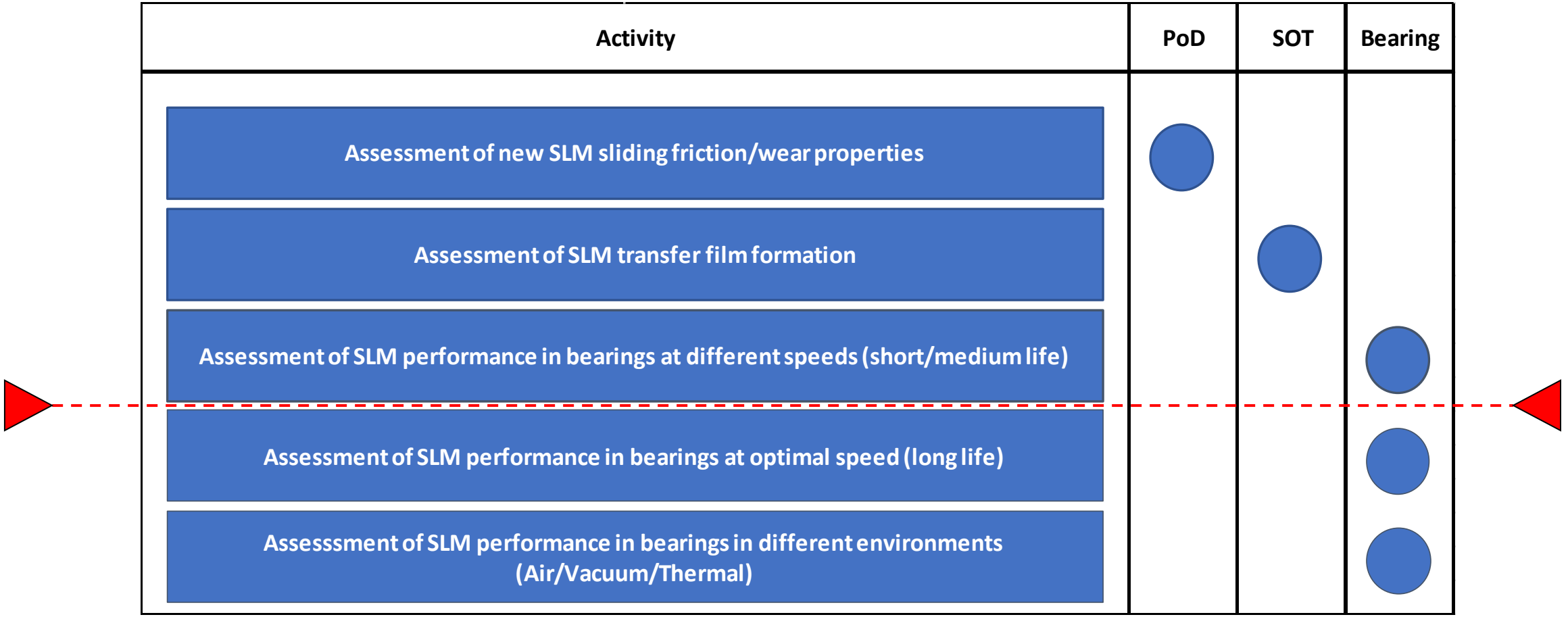

Conclusions

- SOT/ABTR are useful tools in the evaluation of SLMCs candidates.
- Facilities can be used to characterise transfer films in both a qualitative and quantative manner.
- Testing shows that TSE8591 is a very encouraging candidate for replacing PGM-HT.

Acknowledgements

- ESTL acknowledge the following:
  - ESA TEC/MSM for project management and guidance
  - AAC/Ensinger for providing materials from SLMC project

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